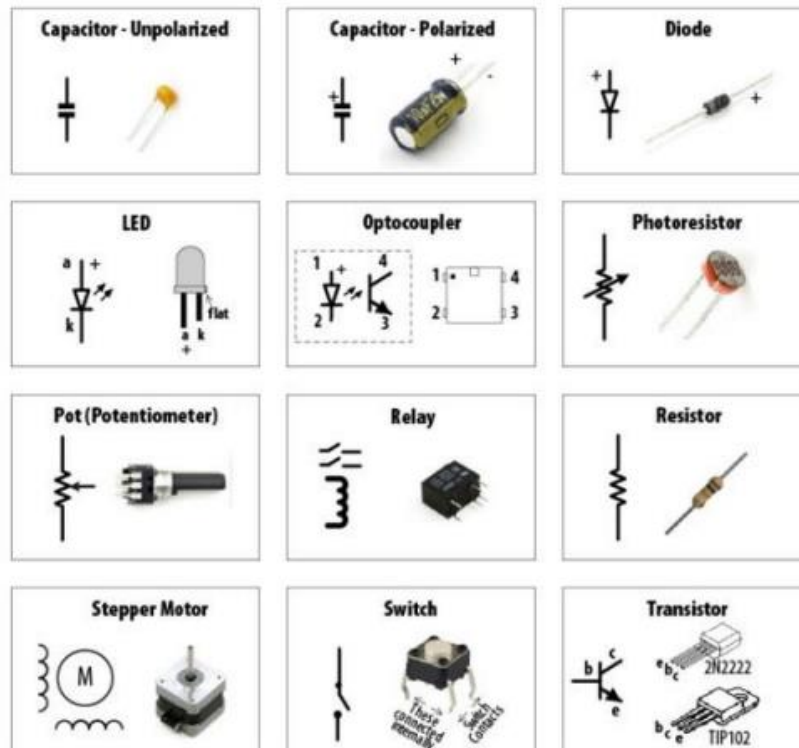


Information:

- Common Electrical Components
- Resistor Chart and Capacitors Codes
- Breadboards and some simple wiring layouts
- Using a Multimeter
- Series and Parallel Resistor Formulas
- Wheatstone Bridge Formulas

Some History: While analog devices have been supplanted by their digital equivalents in many applications, they are still widely used and remain engrained in engineered devices. An analog output format is often ergonomically superior in monitoring, as evidenced by modern car speedometer dials and dial wristwatches. Too often we qualify a digital device by its digital readout, but internal analog circuits form the foundation for both analog and many digital indicating systems. In fact, many of the systems that we interface with are analog and digital hybrids. Within a signal chain, it is common to find digital and analog electrical devices being used together and so requiring special signal conditioning. An understanding of analog device function provides insight, as well as a historical reference point, into the advantages and disadvantages of digital counterparts.

Common Electrical Components:

Capacitors (passive electrical elements)



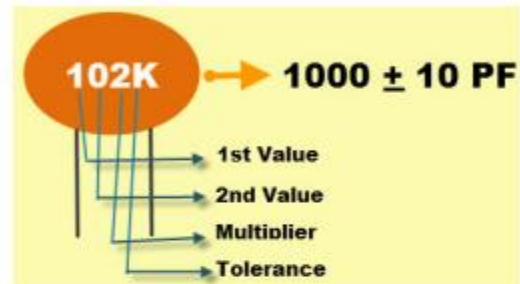
Polarized Capacitor



Non-polarized Capacitor

Capacitor Codes

| Code | Tolerance | Code | Tolerance |
|------|-----------------------|------|-------------|
| A | $\pm 0.05 \text{ pF}$ | K | $\pm 10 \%$ |
| B | $\pm 0.1 \text{ pF}$ | L | $\pm 15 \%$ |
| C | $\pm 0.25 \text{ pF}$ | M | $\pm 20 \%$ |
| D | $\pm 0.5 \text{ pF}$ | N | $\pm 30 \%$ |
| E | $\pm 0.5 \%$ | P | -0 to 100 % |
| F | $\pm 1 \%$ | S | -20 to 50 % |
| G | $\pm 2 \%$ | W | -0 to 200 % |
| H | $\pm 3 \%$ | X | -20 to 40 % |
| J | $\pm 5 \%$ | Z | -20 to 80 % |



Resistors

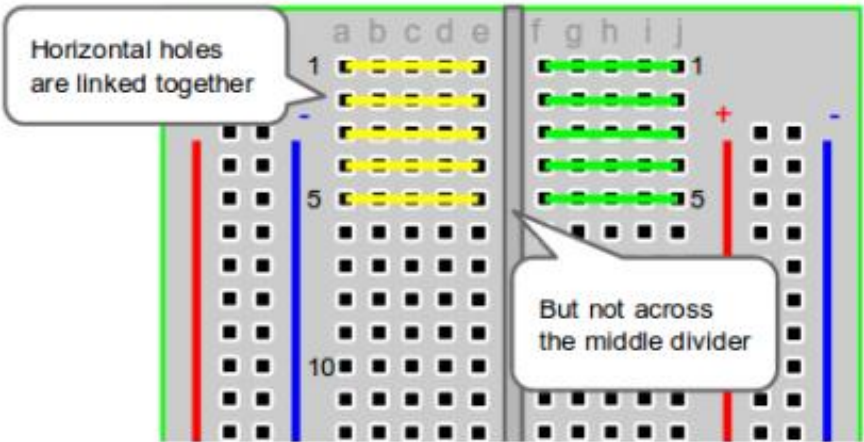
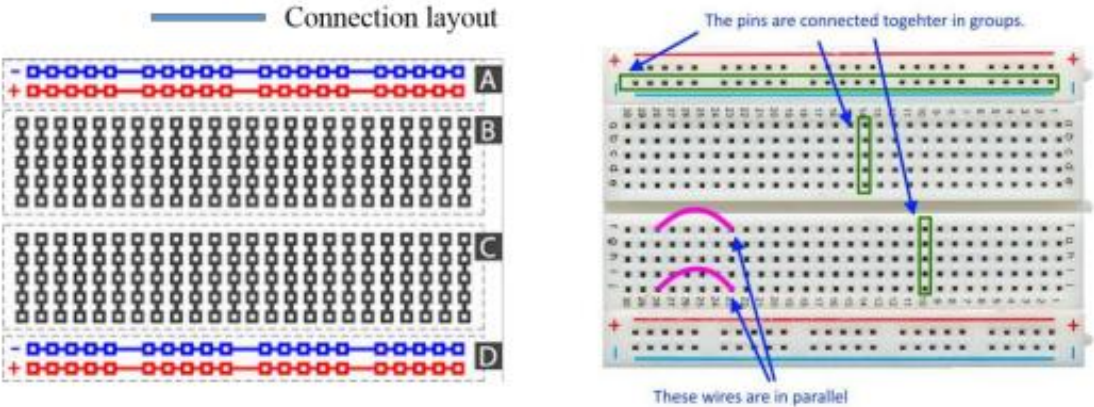


Resistor Chart

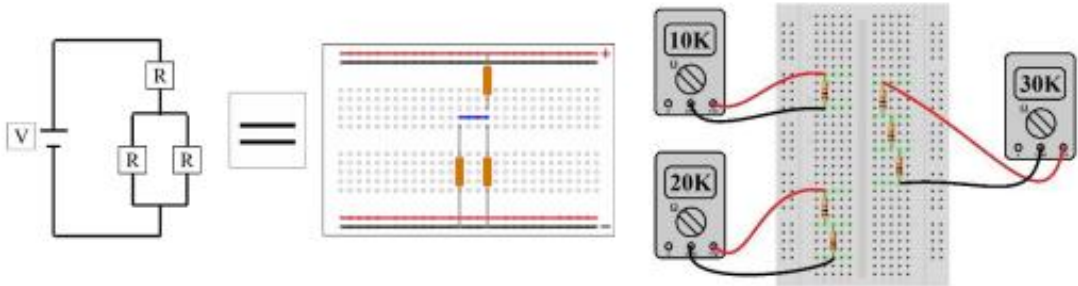
| 4-Band-Code | | | | | |
|-------------|----------------------|------------------------|----------------------|---------------|------------------|
| 2%, 5%, 10% | | 560k Ω \pm 5% | | | |
| COLOR | 1 ST BAND | 2 ND BAND | 3 RD BAND | MULTIPLIER | TOLERANCE |
| Black | 0 | 0 | 0 | 1 Ω | |
| Brown | 1 | 1 | 1 | 10 Ω | $\pm 1\%$ (F) |
| Red | 2 | 2 | 2 | 100 Ω | $\pm 2\%$ (G) |
| Orange | 3 | 3 | 3 | 1K Ω | |
| Yellow | 4 | 4 | 4 | 10K Ω | |
| Green | 5 | 5 | 5 | 100K Ω | $\pm 0.5\%$ (D) |
| Blue | 6 | 6 | 6 | 1M Ω | $\pm 0.25\%$ (C) |
| Violet | 7 | 7 | 7 | 10M Ω | $\pm 0.10\%$ (B) |
| Grey | 8 | 8 | 8 | | $\pm 0.05\%$ |
| White | 9 | 9 | 9 | | |
| Gold | | | | 0.1 Ω | $\pm 5\%$ (J) |
| Silver | | | | 0.01 Ω | $\pm 10\%$ (K) |

| 5-Band-Code | | | | | |
|-----------------------|--|-----------------------|--|--|--|
| 0.1%, 0.25%, 0.5%, 1% | | 237 Ω \pm 1% | | | |

Breadboard: Pin diagram

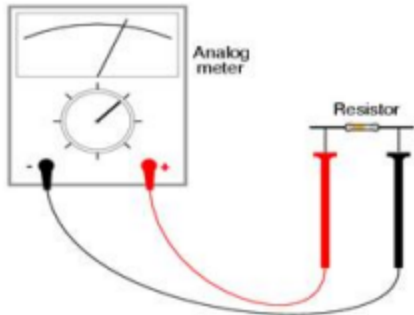


Breadboard Layouts: 2 examples



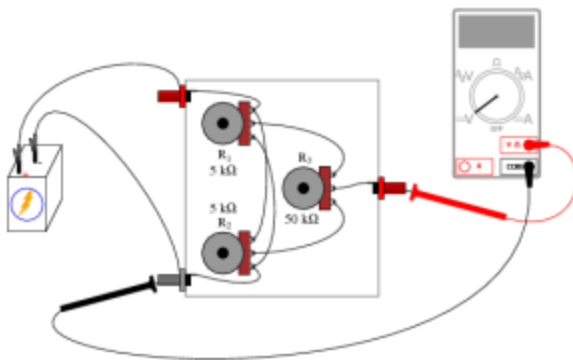
Taking Measurements with a Digital Multimeter

STUDY YOUR USER MANUAL!



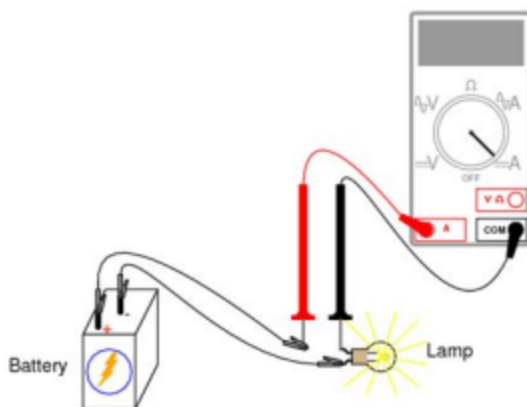
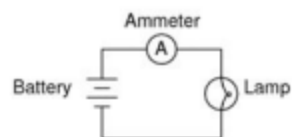
Measuring Resistance

- Doesn't require a power source
- Can measure outside of a circuit
- If you are detecting resistance in a circuit, be sure to have the power supply OFF



Measuring Voltage

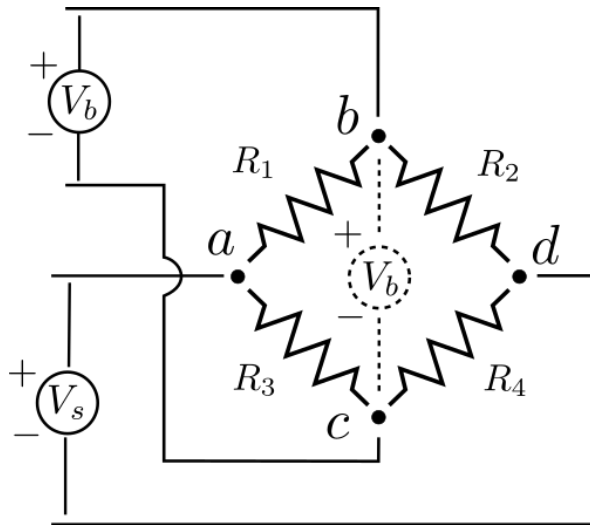
- Just probe the existing circuit.
- The meter is NOT part of the circuit



Measuring Current

- MUST have meter as part of the circuit
- The wiring of the circuit MUST be altered
- Allow the meter to be placed in series in the circuit at the point where the current is to be measured

Wheatstone Bridge Circuit – Used for detecting small resistance changes



Bridge Voltage Relationship:

$$V_b = V_s \left(\frac{R_1}{R_1 + R_2} - \frac{R_3}{R_3 + R_4} \right)$$

Note: for more information see ME3023 lecture Modules: *Strain, Strain Applications*

equation and figure adapted from Theory and Design for Mechanical Measurements Ch. 11